Projecting device for displaying computer images

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a projecting device, and more particularly, to a projecting device for displaying computer images.

2. Description of the prior art

Digital micro-mirror devices are often used as image modules in reflective projecting devices for generating images by reflection and for projecting images. However, the distances between incident light beams and reflected light beams in such projecting devices are often small. Therefore, in order to avoid unwanted interference between light beams, the projecting devices must be made very large.

Please refer to Fig.1. Fig.1 is a perspective view of a prior art reflective projecting device 10. The reflective projecting device 10 comprises a reflective image module 12 comprising a plurality of controllable reflective surfaces (not shown) for modulating an incident light beam 11 and generating an image-containing reflected light beam 13, a total reflecting prism 14 for preventing interference between the incident light beam 11 emitted to and the reflected light beam 13 reflected from the image module 12, an optical device 16 such as a dichromatic mirror or a dichromatic prism, and a projecting lens 18 for focusing the image-containing reflected light beam 13 and outputting the image.

The projecting device 10 uses the total reflecting prism

14 to prevent unwanted interference between the incident light beam 11 emitted to and the reflective light beam 13 reflected from the image module 12. A long post focal distance 19, i.e. a long distance between the image module 12 and projecting lens 18, is therefore required. Therefore, the projecting device 10 must be very large and complicated leading to increased manufacturing cost. The prism 14 shortens ray traces of the incident light beam 11 and the reflective light beam 13 but also refracts light which causes chromatic aberrations and deterioration of the image. Also, the prism 14 reflects undesired deviated light onto the projecting lens 18 which lowers image contrast. Finally, assembly requirements for the total reflecting prism 14 are rigid which increases complexity of the structure and cost of manufacturing.

SUMMARY OF THE INVENTION

It is therefore a primary objective of the present invention to provide a projecting device to solve the above mentioned problems.

In a preferred embodiment, the present invention provides a projecting device comprising:

a light source for generating an incident light beam;

a reflective image module comprising a plurality of controllable reflective surfaces for modulating the incident light beam and generating a reflected image-containing light beam;

a first lens set for concentrating the incident light beam;

a reflective mirror for reflecting the incident light beam from the light source onto the image module through the first lens set; and

a second lens set installed between the light source and the reflective mirror for shortening an optical path from the

light source to the reflective mirror;

wherein the optical path of the incident light beam reflected from the image module intersects a plane formed by the optical paths of the incident light beam from the light source to the reflective mirror and from the reflective mirror to the image module at one point.

It is an advantage of the present invention that the lens sets and the reflective mirror of the projecting device are specially arranged to prevent light crossings and to shorten the optical path thereby reducing the overall size of the projecting device. Moreover, the projecting device does not use prisms and so there is no generation of chromatic aberrations and no deviation of light. This results in ease of installation and lower manufacturing costs.

This and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiment which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWING

Fig.1 is a schematic view of a prior art reflective projecting device.

Fig.2 is a schematic view of a projecting device according to the present invention.

Fig.3 is a ray trace diagram of the light beam shown in Fig.2.

Fig.4 is a positioning diagram showing relative positions of the first and second lens sets shown in Fig.2.

Table.1 is a list of the reference optical data in the first preferred embodiment.

Table.2 is a list of the reference optical data in the second preferred embodiment.

Table.3 is a list of the reference optical data in the third preferred embodiment.

Table.4 is a list of the reference optical data in the fourth preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Please refer to Fig.2. Fig.2 is a schematic view of a projecting device 20 according to the present invention. The projecting device 20 comprises a light source 21, a third lens set 26, a rotatable color wheel 40, a second lens set 28, a reflective mirror 30, a first lens set 32, a reflective image module 34, a projecting module 36, and a control module 38 for outputting image control signals to the image module 34.

The light source 21 comprises a light bulb 22 and a curved reflective mirror 24 and produces a first incident light beam 46. A third lens set is installed between the light source 21 and a rotatable color-filtering color wheel 40 for focusing the first incident light beam 46 onto the color filters. The rotatable color wheel 40 rotates to color the first incident light beam 46 for sequentially producing red, green, and blue lights. The filtered first incident light beam 46 then passes through the second lens set 28 which shortens the optical path of the first incident light beam 46 to the reflective mirror 30 where it is reflected to the first lens set 32 which concentrates this second incident light beam 48 onto the image module 34. The image module 34 could be a reflective liquid crystal display or a digital micro-mirror device which comprises a plurality of individually controllable micro-mirrors arranged in matrix formation. Based on control signals received from the control module 38, the image module 34

modulates the second incident light beam 48 to produce an image-containing reflected light beam 50 which is passed to the projecting module 36 where it is focused and outputted.

The rotatable color wheel 40 comprises a plurality of transparent red, green and blue color filters 48 each installed at positions 42 on a round panel 41 equidistant from its center. The rotatable color wheel rotates at a constant speed along its axis 45 to filter the first incident light beam 46 to sequentially produce red, green and blue lights in turn. This filtered reflected light beam 50 is output in the appearance of a composed image due to persistence of vision of the user.

The first and second lens sets 32, 28 of the projecting device 20 have positive diopters that substantially reduce the total length of the optical path of the incident light beam 46 from the light source 21 to the image module 34. After processing by the color filters, the incident light beam 46 is ultimately concentrated on the image module 34 with maximum light usage efficiency by that the concentrated spot size of the incident light beam 46 is just enough to cover the entire reflective surface of the image module 34. The reflective mirror 30 and image module 34 are arranged at angles such that crossing of the light beams in three-dimensional space of the incident light beam 48, the reflected light beam 50 and the incident light beam 46 is prevented. This in turn allows greater reduction in the size of the projecting device 20.

Please refer to Fig.3. Fig.3 is a ray trace diagram of the light beams 46, 48, and 50 in a three-dimensional space formed by x, y, and z-axes. The first incident light beam 46 is generated by the light source 21, and then travels through the optic axis of the third and second lens sets 26 and 28

to the reflective mirror 30 where it is reflected to pass through the first lens set 32 to become the second incident light beam 48. The angle between the optic axis and the x-axis is between 0 to 15 degrees. The second incident light beam 48 is then reflected by the image module 34 in the X-Y plane to form the reflected light beam 50, which is then emitted through the projecting module 36. Fig. 3 also shows that the normal line 51 (the positive z-axis) of the reflective surface of the image module 34 intersects the plane formed by light beams 46 and 48 at zero point. The position of the y-axis of the image module 34 is higher than the position of the y-axis of the reflective mirror 30 and the light source 21 but lower than that of the projecting module 36.

Wherein the angle α between the reflected light beam 50 and the normal line 51 (positive direction of z-axis) of the image module 34 is between 2 to 18 degrees, the angle θ between the second incident light beam 48 along the optic axis of the first lens set and the normal line 51 is between 21 to 35 degrees and the angle ϕ between an x-y plane projection line 53 of the optic axis of the first lens set 32 and the x-axis is between -48 to -68 degrees. The lens sets 26, 28 and 32 together with the reflective mirror 30 can form a bent optical path 46, 48 throughout its course through the optic axis and between each lens set. This 3-D design can dramatically reduce the volume of the projecting device 20.

In the projecting device 20, the first lens set 32 could be a positive lens of aspherical plane-convex or aspherical biconvex, and the conic of the positive lens is between -1.2 and -0.45. Also, in order to maintain light efficiency while diminishing the height of the projecting device 20 and preventing interference of the reflected light beam 50 generated by the image module 34 with the first lens set 32,

areas not occupied by the incident light beam 48 are eliminated to prevent shading of the reflected light beam 50. Further reduction of the size of the projecting device 20 may be achieved by making the angle between light beams 48 and 50 as small as possible.

In the projecting device 20, the second lens set 28 usually comprises two positive lenses. The size of the image module 34 may be changed to accommodate improvements in its resolution. The size of the image module 34 may be minimized while maintaining high efficiency of light usage if the two lens sets 28, 32 fit the following conditions:

$$1.1 \le \frac{|F_A + F_B|}{F_A} \le 1.7,$$

$$0.5 \le \sqrt{\left|\frac{F_B}{F_{AB}}\right|} \le 1.1,$$

where F_A is the focal length of the first lens set, F_B is the focal length of the second lens set, and F_{AB} is the combined focal length of the two lens sets.

Please refer to Fig.4. Fig.4 is a positioning diagram showing relative positions of the first and second lens sets 32, 28. The second lens set 28 comprises a first lens 27 and a second lens 29. The first lens 27, second lens 29, and first lens set 32 are aspherical lenses each comprising a front side and a rear side. The incident light beam 46 passes through a color filter 43 of the rotatable color wheel 40, the front side 52 of the first lens 27, the rear side 54 of the first lens 27, the front side 56 of the second lens 29, the rear side 58 of the second lens 29, the front side 60 of the first lens set 32, and the rear side 62 of the first lens set 32, and forms the incident light beam 48 which is passed onto the image module 34.

Please refer to Table 1 to Table 4. There are a variety of designs in the indexes of refraction, the radii of curvature of the front side and the rear side, the relative positioning of the first lens 27, second lens 29, and the first lens set 32. Table 1 to Table 4 illustrate four preferred embodiments. The thickness of the first lens 27 (d2) is 6mm, the distance from the first lens 27 to the second lens 29 (d3) is 1mm; the thickness of the second lens 29 (d4) is 6mm, the distance of the second lens 29 to the first lens set 32 (d5) is 70mm, and the thickness of the first lens set 32 (d6) is 17mm. The index of refraction of each lens is calculated corresponding to a wavelength 0.587μm. The conic of the first lens 32 in Table 2 is -1.00 and is -0.97 in Tables 1, 3 and 4. Other related optical data are listed in Table 1 to Table 4.

In the present invention, the lens sets 28,32 and the reflective mirror 30 of the projecting device 20 are arranged so as to shorten the optical paths and prevent crossing of light beams thereby reducing the overall size of the projecting device. Since the projecting device 20 does not contain prisms, there is no generation of chromatic aberrations and deviations of light. This results in ease of installation and lower manufacturing costs.

Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should by construed as limited only by the metes and bounds of the appended claims.